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Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products

Quarterly Report

December 30, 1995 - March 30, 1996

Work Performed Under Contract No.: DE-FC21-94MC31175

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

By
University of Pittsburgh
Center for Energy Research
1140 Benedum Hall
Pittsburgh, Pennsylvania 15261

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EXECUTIVE SUMMARY

During the second quarter of Phase 2, work continued on evaluating Phase 1 samples, preparing reports and presentations, and addressing early details of the field work.

Laboratory Analyses

Final analyses for arsenic, selenium and mercury were completed for the extracts of the three by-products collected in Phase 1. All metals concentrations in the extracts were below the current BDAT standard and only selenium in the TCLP extract of two samples of the residues from the Ebensburg Power Company exceeded the potential future BDAT standard of 0.16 mg/L.

Final analyses for arsenic, beryllium, copper, mercury, selenium, antimony, thallium and vanadium were completed for the extracts of the eight immediately successful by-product/waste mixtures and the five mixtures which were not immediately successful, prepared during Phase 1. All concentrations were below both the current and potential future BDAT standards.

The two graduate students assigned to this project have begun preparation of their M.S. theses, one on the mechanism of stabilization and the other on comparison of various treatment chemicals.

Preparation for Field Work

The Waste Management Division, Southwest Region, Pennsylvania Department of Environmental Protection (PADEP) approved the field work for Phase 2 at the Yukon Plant of Mill Service, Inc. The Air Pollution Control Division, Southwest Region, PADEP exempted the field work at the Yukon Plant from its Plan Approval/Operating Permit.

Reports and Presentations

The Draft Topical Report for Phase 1 was submitted to the Morgantown Energy Technology Center (METC) on March 1, 1996.

The fifth quarterly technical report was submitted to METC on March 25, 1996.

A paper entitled, "Stabilization of Metal-Laden Hazardous Wastes Using Lime-Containing Ash from Two FBC's and a Spray-Drier" was presented at the 211th American Chemical Society National Meeting and Exposition in New Orleans, Louisiana on March 25, 1996. The co-principal investigators of this project both attended the meeting.

Plans for the Next Quarter

During the quarter from March 31 through June 30, 1996, work will continue on Tasks 3 through 5 of Phase 1, which remain uncompleted at the end of the current quarter. This will involve:

- Attempting to identify a fourth by-product and another four wastes
- Treating the wastes so identified with the three current by-products and the fourth one, if identified, in the laboratory
- Adding this information to the database of the project.

Also during the next quarter work will proceed on the Test Plan for Phase 2. The completion of the Test Plan will depend upon receipt of environmental approval from U.S. DOE. Finally, during the next quarter the graduate students will carry out a significant portion of the special studies planned for their M.S. theses.

INTRODUCTION

This sixth quarterly report describes work done during the sixth three-month period of the University of Pittsburgh's project on the "Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products."

Participating with the university on this project is Mill Service, Inc.

This report describes the activities of the project team during the reporting period. The principal work has focussed upon completing laboratory evaluation of samples produced during Phase 1, preparing reports and presentations, and seeking environmental approvals and variances to permits that will allow the field work to proceed.

LABORATORY AND FIELD WORK

Laboratory Analyses

Phase 1 laboratory work at the University of Pittsburgh was continued through the quarter. The work completed consisted of final analysis of ASTM and TCLP extracts of by-products and by-product/waste mixtures by atomic absorption spectroscopy.

By-Product Analyses

Analysis of all ASTM extracts of the by-products was completed with measurement of the concentrations of the following three metals: As, Se and Hg. In addition, the TCLP extracts of all the by-products were analyzed for As and Se. It should be noted that As was analyzed by USEPA SW-846 Method 7060A (Atomic Absorption, Furnace Technique) instead of Method 7061 (Atomic Absorption, Gaseous Hydride) as previously stated in the Phase 1 Test Plan. In addition, Se was analyzed by USEPA SW-846 Method 7740 (Atomic Absorption, Furnace Technique) instead of Method 7741 (Atomic Absorption, Gaseous Hydride) as previously stated in the Phase 1 Test Plan. A summary of the metals analysis completed on ASTM and TCLP extracts of the by-products is given in Tables 1 and 2, respectively.

All metals concentrations of the ASTM and TCLP by-product extracts were found to be below the current BDAT standards. In addition, all metals concentrations of the ASTM and TCLP by-product extracts were found to be below the potential future standards except for the Se concentration of the TCLP extracts of EPC #4 and 5, which exceeded the potential future standard of 0.16 mg/L.

TABLE 1: METAL ANALYSIS OF ASTM EXTRACTS OF BY-PRODUCTS†

Metal	CONSOL #1	CONSOL # 5	CONSOL #7	Tidd #2	Tidd #8	Tidd #10	EPC #2	EPC #3	EPC #4	EPC #5	Thames River #2	Thames River #4
As	<0.01	<0.01	<0.01	0.020	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.012
Hg	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Se	<0.01	<0.01	<0.01	0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

† All concentrations are in units of mg/L

TABLE 2: METAL ANALYSIS OF TCLP EXTRACTS OF BY-PRODUCTS†

Metal	Current BDAT Standard	Potential Future Standard	CONSOL #5	CONSOL #7	Tidd #8	Tidd #10	EPC #2	EPC #4	EPC #5	Thames River #2	Thames River #7
As	5.0	5.0	0.046	<0.01	0.019	<0.01	0.165	0.134	0.158	0.015	<0.01
Se	1.0	0.16	0.016	0.013	<0.01	<0.01	0.078	0.254	0.201	0.025	0.025

† All concentrations are in units of mg/L

By-Product/Waste Mixtures

Analysis of all ASTM extracts of immediately successful by-product/waste mixtures was completed with measurement of the concentrations of the following eight metals: As, Be, Cu, Hg, Se, Sb, Tl and V. In addition, the TCLP extracts of immediately successful by-product/waste mixtures were analyzed for the following seven metals: As, Be, Cu, Se, Sb, Tl and V. A summary of the metals analysis completed on 24-hour ASTM and 90-day TCLP extracts of the immediately successful treated wastes is given in Tables 3 and 4, respectively.

TABLE 3: METAL ANALYSIS OF 24-HOUR ASTM EXTRACTS OF BY-PRODUCT/WASTE MIXTURES†

Metal	CONSOL/ Battery Sludge	CONSOL/ Munitions Soil	Tidd/ Battery Sludge	Tidd/ Industrial Soil	Tidd/ Munitions Soil	Tidd/ WWTP Soil	EPC/ Munitions Soil	EPC/ WWTP Soil
As	<0.01	<0.01	<0.01	0.012	0.012	0.012	<0.01	<0.01
Be	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	<0.05	0.06	<0.05	<0.05	0.06	<0.05	<0.05	<0.05
Hg	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Sb	<0.020	<0.020	0.101	0.056	<0.020	<0.020	<0.020	<0.020
Se	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tl	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
V	<0.010	<0.010	<0.010	<0.010	0.021	0.017	0.016	0.024

† All concentrations are in units of mg/L

All metals concentrations of the ASTM and TCLP extracts of the by-product/waste mixtures were found to be below both the current BDAT standards and the potential future standards (where applicable).

TABLE 4: METAL ANALYSIS OF 90-DAY TCLP EXTRACTS OF BY-PRODUCT/WASTE MIXTURES†

Metal	Current BDAT Standard	Potential Future Standard	CONSOL/ Battery Sludge	CONSOL/ Munitions Soil	Tidd/ Battery Sludge	Tidd/ Industrial Soil	Tidd/ Munitions Soil	Tidd/ WWTP Soil	EPC/ Munitions Soil	EPC/ WWTP Soil
As	5.0	5.0	0.012	0.041	<0.01	<0.01	<0.01	<0.01	0.069	0.124
Be	---	0.014	<0.001	0.0040	<0.001	<0.001	<0.001	<0.001	0.0025	0.0027
Cu	---	---	0.08	0.97	<0.05	0.13	0.09	<0.05	0.82	0.09
Sb	---	2.1	0.242	0.024	0.107	0.238	0.026	<0.020	<0.020	<0.020
Se	5.7	0.16	0.028	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tl	---	0.078	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
V	---	0.23	0.074	0.101	0.011	<0.010	0.013	<0.010	0.019	0.032

† All concentrations are in units of mg/L

For those treatments that did not prove immediately successful, the 28 and 90-day TCLP extracts were analyzed for the same seven metals as mentioned above. A summary of the metals analysis completed on the TCLP extracts of the by-product/waste mixtures prepared by the Proctor method is given in Tables 5 and 6.

TABLE 5: METAL ANALYSIS OF 28-DAY TCLP EXTRACTS OF BY-PRODUCT/WASTE MIXTURES PREPARED BY THE PROCTOR METHOD[†]

Metal	Current BDAT Standard	Potential Future Standard	CONSOL/ Industrial Soil	Tidd/ Munitions Soil	EPC/ WWTP Soil
As	5.0	5.0	0.030	<0.01	0.071
Be	—	0.014	0.0114	<0.001	0.0029
Cu	—	—	0.52	0.14	0.20
Sb	—	2.1	<0.020	0.102	<0.020
Se	5.7	0.16	<0.01	<0.01	<0.01
Tl	—	0.078	<0.005	<0.005	<0.005
V	—	0.23	0.097	<0.010	0.020

[†] All concentrations are in units of mg/L

All metals concentrations of the ASTM and TCLP extracts of the by-product/waste mixtures prepared by the Proctor method were found to be below both the current BDAT standards and the potential future standards (where applicable).

TABLE 6: METAL ANALYSIS OF 90-DAY TCLP EXTRACTS OF BY-PRODUCT/WASTE MIXTURES PREPARED BY THE PROCTOR METHOD†

Metal	Current BDAT Standard	Potential Future Standard	CONSOL/ Industrial Soil	Tidd/ Munitions Soil	EPC/ WWTP Soil
As	5.0	5.0	0.013	<0.01	<0.01
Be	—	0.014	0.0072	<0.001	<0.001
Cu	—	—	4.32	0.07	0.06
Sb	—	2.1	0.101	<0.020	<0.020
Se	5.7	0.16	<0.01	<0.01	0.021
Tl	—	0.078	<0.005	<0.005	<0.005
V	—	0.23	0.045	<0.010	0.014

† All concentrations are in units of mg/L

Scholarly Activity

The two graduate students, Vourneen Clifford and Jesse Pritts, who are carrying out much of the laboratory analyses and testing at the University of Pittsburgh for this project, have begun to plan the special scholarly studies they will perform for their master's theses.

Mechanism of Stabilization

Ms. Clifford plans to examine the mechanism of stabilization (homogeneous precipitation, encapsulation or inclusion in heterogeneous crystal structures).

Materials

The materials utilized in this research will include three CCT by-products, three metal-laden hazardous wastes, and nine by-product/waste mixtures. A brief description of these materials is given below.

CCT By-Products. Three advanced clean coal technology by-products will be utilized. These are identical to the ones being used on the project.

- Residue from a Coal-Waste-Fired Circulating Fluid Bed Combustor (CFBC), operated by the Ebensburg Power Company in Ebensburg, Pennsylvania. The residue is a relatively coarse material, as it consists of both bottom ash and fly ash from the boiler, and contains 82% ash, 12.5% limestone equivalent, and 5.5% $CaSO_3/CaSO_4$.

- Residue from a Coal-Fired Pressurized Fluid Bed Combustor (PFBC) at the Tidd Station of the Ohio Power Company, a subsidiary of the American Electric Power Corporation, in Brilliant, Ohio. The sorbent fed to the plant was dolomite, rather than lime or limestone. The chemical composition of the residue is 50-60% equivalent $CaCO_3$ and 1-2% available (free or uncombined) CaO.

- Residue from a Spray Dry Scrubber, supplied from a Joy Niro Spray Dryer by CONSOL Inc. The material is produced by the cogeneration project of Chambers Cogeneration Limited Partnership, operated by U.S. Operating Services Company at the Carneys Point Cogeneration Plant on the grounds of DuPont's Chambers Works in New Jersey. The residue contains 45% fly ash, 36% $CaSO_3/CaSO_4$, 10% $Ca(OH)_2$, 2% $CaCO_3$, and 7% other inert material.

Metal-Laden Hazardous Wastes. Three metal-laden hazardous wastes will be obtained from among those wastes received for treatment at the Yukon Plant of Mill Service, Inc. The most likely sources will be heavy metal contaminated soils and sandblast wastes.

Treated Wastes. Each of the three hazardous wastes will be treated with each of the three by-products at a weight ratio of 70% waste/30% by-product, resulting in a total of nine by-product/waste mixtures.

Methods

For each of the three by-products and each of the three hazardous wastes, the following analyses will be performed:

- Metals analysis of TCLP extracts (US EPA SW-846 Method 1311) to determine the concentrations of metals of concern.

- X-ray diffraction (XRD) to determine the crystalline phases present in order to locate them in the microstructure.

- Scanning electron microscopy (SEM) to create a magnified image of the surface in order to observe the microstructure.

Each of the three metal-laden hazardous wastes will be treated with each of the three by-products at a weight ratio of 70% waste/30% by-product, resulting in a total of nine by-product/waste mixtures. From these mixtures, cylinders measuring 3 x 6 inches will be molded and cured in a humidity room with a relative humidity of approximately 100%.

After curing times of 3 and 28 days, these nine treated waste samples will be analyzed as follows:

- Metals analysis of TCLP extracts (US EPA SW-846 Method 1311) to determine the effectiveness of stabilization.

- XRD (the powder sample must pass a 325 mesh sieve) to determine the phases present.

- SEM to create a magnified image of the surface in order to observe the microstructure.

Results and Discussion

The results of this research will fall into two categories:

- Results of metals analysis of TCLP extracts will determine the ability of CCT by-products to successfully stabilize metal-laden hazardous wastes.

- Results of XRD and SEM analysis will give insight into the microstructure and morphology and provide a better understanding of the fixation mechanism responsible for stabilization.

Comparison of Various Treatment Chemicals

Mr. Pritts plans to evaluate the performance of CCT by-products in comparison with traditional treatment chemicals as stabilizers of metal-laden hazardous waste.

Materials

The materials required for this evaluation are of two types — treatment chemicals and hazardous wastes.

Treatment Chemicals. Six treatment chemicals will be considered for use in stabilizing the three hazardous wastes that will be chosen for testing.

- Residue from a coal-waste-fired circulating fluidized bed combustor. This material is from a unit operated by the Ebensburg Power Company at Ebensburg, Pennsylvania. The residue contains 82% ash, 12.5% limestone equivalent and 5.5% $CaSO_3/CaSO_4$. It is relatively coarse material, as it contains both bottom ash and fly ash from the boiler.

- Dry scrubber residue, supplied by CONSOL, Inc., from a Joy Niro Spray Drier. This material is produced by the cogeneration project of Chambers Cogeneration Limited Partnership, operated by U. S. Operating Services Company on the grounds of DuPont's Chambers Works in New Jersey. The residue contains The residue contains 45% fly ash, 36% $CaSO_3/CaSO_4$, 10% $Ca(OH)_2$, 2% $CaCO_3$ and 7% other inert material. It is composed of agglomerates of fine materials, formed in the scrubber.

- Residue from a coal-fired pressurized fluidized bed combustor. This material is from the Tidd Station of Ohio Power Company, a subsidiary of American Electric

Power Corporation, at Brilliant, Ohio. The material contains 50-60% equivalent $CaCO_3$, 1-2% available CaO and approximately 40-50% fly ash.

- Type I Portland cement. Type I is general-purpose Portland cement, which is the most common type of cement used in stabilization/solidification systems. Portland cement is basically a calcium silicate mixture containing predominantly tricalcium and dicalcium silicates (in cement shorthand C_3S and C_2S respectively[1]) with smaller amounts of tricalcium aluminate (C_3A) and a calcium aluminoferrite (C_4AF). Typical weight proportions in an ordinary cement are 50% C_3S, 25% C_2S, 10% C_3A, 10% C_4AF and 5% other oxides.

- High calcium hydrated lime, which is primarily $Ca(OH)_2$. Hydrated lime will be used instead of quicklime (anhydrous) because it is easier and safer to store.

- Class C fly ash from an as yet undetermined source. Class C fly ashes normally result from the burning of sub-bituminous coal and lignite, such as are found in some of the western states of the United States. Class C fly ashes have pozzolanic properties and may also be self-hardening.

Hazardous Wastes. Three heavy metal contaminated hazardous wastes will be chosen for treatments from the following types.

- Contaminated soils
- Air pollution control dusts
- Sandblast wastes
- Incinerator ashes

Laboratory Evaluations

The laboratory evaluations to be conducted include:

- Geo-chemical analysis of treatment chemicals
- Total heavy metals concentrations of treatment chemicals and hazardous wastes
- Leachable heavy metals concentrations of treatment chemicals and hazardous wastes (both water-leachable and acid-leachable)
- Leachable heavy metals concentrations (both water-leachable and acid-leachable) of treated wastes at time periods of zero days and 28 days

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[1] This notation system represents calcium, silicon, aluminum and iron oxides by C, S, A and F, respectively. The subscripts denote the relative mole ratios of each component — for example, 2 $CaO \cdot SiO_2$ is C_2S.

- Compressive strength evaluations of treated wastes at time periods of 7, 14 and 28 days.

The laboratory methods used to obtain the above information include:

- Toxicity Characteristic Leaching Procedure by EPA SW-846 Method 311
- Shake extraction of solid waste with water by ASTM D 3987
- Heavy metal analysis by EPA SW-846 Method 7000A
- Preparation and curing of treated wastes by ASTM C 192
- Unconfined compressive strength of treated wastes by ASTM C 39.

Waste Treatments

Each of the three selected wastes will be treated with a combination of the treatment chemicals at a weight ratio of 70% waste / 30% treatment chemicals. The proposed treatments are:

- 70% waste / 30% by-product (for each of the three by-products)
- 70% waste / 15% Portland cement / 15% lime
- 70% waste / 15% Class C fly ash / 15% lime
- 70% waste / 15% Class C fly ash / 15% Portland Cement

Each mixture will be prepared so as to produce approximately 25 pounds of treated waste (sufficient to fill nine 3" x 6" cylinders). The treatments will be performed by placing the waste and treatment chemicals in a bucket and adding sufficient water to produce a mixture with a slump of 1.5 - 2 inches. Following preparation of each mixture, solidification samples will be prepared by molding the samples in 3" x 6" cardboard cylinders. These samples will then be cured in a controlled environment which will provide sufficient moisture for hydration reactions to take place. The compressive strength of these cylinders will be evaluated after curing times of 7, 14 and 28 days. In addition to the solidification evaluations on each mixture, a TCLP and ASTM water extraction will be prepared for each mixture both immediately after treatment and after the 28 day curing period.

Results

The information that will be obtained from the evaluations include:

- Environmental properties of wastes and treatment chemicals
- Physical/chemical properties of the treatment chemicals

- Environmental properties of treated wastes
  - Immediate TCLP leachable metals
  - Immediate water leachable metals
  - 28-day TCLP leachable metals
  - 28-day water leachable metals
- Engineering properties (compressive strength) of treated wastes.

Discussion

Based on the results obtained, the following points may be discussed:

- Success of CCT by-products as a S/S agent
- Comparison of CCT by-products with commercially used S/S agents
- Effectiveness of S/S based on treatment agent properties
- Effectiveness of S/S based on waste properties
- Effect of TCLP pH on metal stabilization.

<u>Preparation for Field Work</u>

On December 27, 1995, Anthony D. Orlando, the Southwest Regional Manager for Waste Management of the Pennsylvania Department of Environmental Protection (PADEP) wrote to Mill Service, Inc. (MSI), giving approval for the field work of Phase 2, called for in this contract. A copy of this letter is included in Appendix A.

In early January MSI was requested by the Air Pollution Control Division of the Southwest Regional Office of PADEP to provide additional information in support of MSI's request for an exemption from its Plan Approval/Operating Permit. The request appeared to have been initiated in response to information obtained by PADEP during the preparation of the environmental information report by the Center for Hazardous Materials Research last summer. Soon after the requested information was provided by MSI, on February 20, 1996 Noor Nahar, a Southwest Regional Air Pollution Control Engineer — Air Quality — of PADEP wrote to MSI, giving the requested exemption. A copy of this letter is also included in Appendix A.

In anticipation of the decision by the Morgantown Energy Technology Center on whether an environmental assessment will be necessary or a categorical exclusion will be granted under NEPA, MSI prepared an elementary plan for conducting the field tests at MSI's Yukon Plant. This plan will be a significant portion of the Test Plan for Phase 2.

REPORTS AND PRESENTATIONS

Reports

On March 1, 1996 the Draft Topical Report on Phase 1 (August 18, 1994 — August 18, 1995) was submitted to the Morgantown Energy Technology Center (METC) for review and comment.

On March 25, 1996 the Fifth Quarterly Technical Report (the first one of Phase 2) was submitted to METC.

Presentations

On March 25, 1996 James T. Cobb, Jr., presented a paper entitled, "Stabilization of Metal-Laden Hazardous Wastes Using Lime-Containing Ash from Two FBC's and a Spray-Drier" at the 211th American Chemical Society National Meeting and Exposition in New Orleans, Louisiana. Coauthors were R. D. Neufeld, J. Pritts and V. Clifford of the University of Pittsburgh, C. Bender of Mill Service, Inc., and J. Beeghly of Dravo Lime Company. A copy of the preprint of the paper is given in Appendix B.

Work was initiated on two poster presentations. One will be presented by Ronald D. Neufeld at the IAWQ 18th Biennial International Conference in Singapore on June 23-28, 1996. An 1800-word summary of the poster, entitled "Hazardous Waste Stabilization with Clean-Coal Technology Ash Residuals," was submitted to the conference organizers on January 12, 1996. The summary is given in Appendix C.

The second poster presentation will be prepared for a Research Fair to be sponsored by the School of Engineering of the University of Pittsburgh on May 22, 1996 in the William Pitt Union on the university's campus. A portion of the main poster being planned to describe work in the school on environmental issues faced by electric utilities will be devoted to this project.

OUTSIDE CONTACTS

American Chemical Society

James T. Cobb, Jr., and Ronald D. Neufeld attended the 211th American Chemical Society National Meeting and Exposition in New Orleans, Louisiana on March 24-28, 1996. Dr. Cobb presented the paper mentioned earlier.

Preproposal

Ronald D. Neufeld prepared a preproposal on "Stabilization of DOE Hazardous Wastes with Clean-Coal Technology By-Products" in response to Program Notice 96-10 of the Office of Health and Environmental Research, U.S.DOE, Germantown, Maryland. The proposed research is an outgrowth of the work currently being carried out under this contract.

Dravo Lime Company

Joel Beeghly, director of the subcontract to Dravo Lime Company for Phase 1 of this project, continues to provide observations and advice to the project team. He alerted the team to several items of interest during the period covered by this project.

- Calls for papers for the Symposium on Testing Soil Mixed with Waste or Recycled Materials, American Society for Testing and Materials, January 16-17, 1997, New Orleans, Louisiana, and the Twelfth International Symposium on Management & Use of Coal Combustion Byproducts (CCBs), American Coal Ash Association, January 26-30, 1997, Orlando, Florida. The project team decided not to submit proposals to either conference. It is felt that the Test Plan for Phase 2 needs to be in operation before commitments are made for the first presentation on that portion of the project.

- Article on "Electrostatic Separation of Powdered Material: Beneficiation of Coal and Fly Ash" in *Energeia*, vol 6, no. 4, 1995 from the Center for Applied Research, University of Kentucky.

- Preliminary Program of the 1996 Unburned Carbonaceous Material in Utility Fly Ash Conference, sponsored by the Pittsburgh Energy Technology Center, U.S.DOE.

- Observations on the swelling behavior of utilized by-products. FBC material swells when placed in road-base, because of ettringite which forms expanded hydrates in a high-pH environment. PFBC material from the Tidd Station, on the other hand, does not swell, because it contains no free lime. The spray-drier material from CONSOL does not swell either, even though it induces a high-pH environment.

ADMINISTRATIVE ASPECTS

This section provides the monthly highlights and then closes by comparing progress with the milestone chart.

Monthly Highlights

Here are the highlights of the second three months of the second phase of the project.

December 30, 1995 - January 30, 1996

- Approval for the field test at the Yukon Plant of Mill Service, Inc., is received from the Waste Management Division, Southwest Region, of the Pennsylvania Department of Environmental Protection (PADEP).

January 30 - February 29, 1996

- Exemption is received from the Air Pollution Control Division, Southwest Region, of the PADEP, allowing the field test at the Yukon Plant of Mill Service, Inc.

February 29 - March 30, 1996

- Final metal analyses are completed for all samples prepared during Phase 1.
- Draft Topical Report on Phase 1 is submitted to Morgantown Energy Technology Center.
- Paper on "Stabilization of Metal-Laden Hazardous Wastes Using Lime-Containing Ash from Two FBC's and a Spray-Drier" is presented at the 211th American Chemical Society National Meeting and Exposition in New Orleans, Louisiana.
- Fifth quarterly technical report issues.

Comparison of Progress with Milestone Chart

The following task for Phase 2 had been scheduled for completion during the first quarter of Phase 2:

- Task 1 - Test Plan for Phase 2

Task 1 still was not completed during the second period of this phase. The review of the environmental information report had not been completed at METC.

By submitting the fifth quarterly technical report on March 25, 1996, the project team met one of its reporting requirements for this period.

Work continued on five tasks from Phase 1:

- Task 3 - Sample Collection and Characterization
- Task 4 - Treatment of Metal-Laden Waste with CCT Solid By-Product
- Task 5 - Data Analysis
- Task 6 - Economic Analysis
- Task 7 - Topical Report

Tasks 6 and 7 were completed on March 1, 1996. Work on Tasks 3, 4 and 5 of Phase 1 will continue into the third quarter of Phase 2. The fourth by-product and the final four wastes are still being sought. As they are identified, they will be evaluated and the resulting data will be analyzed.

PLAN FOR THE NEXT QUARTER

During the quarter from March 30 through June 30, 1996, work will continue on Tasks 3 through 5 of Phase 1. The search for a fourth by-product will continue, focussing next upon coal-fired FBC residue. Mill Service, Inc. will watch for additional wastes to add to the list, particularly a paint sandblasting residue.

Work on Task 1 of Phase 2 will continue. The Test Plan for Phase 2 will include the detailed plan for the field work and related laboratory activities scheduled to end on September 30, 1996. If, however, the environmental approval is delayed much longer, the project will have to be extended into the third year, because treatment of solids tends to be a seasonal (summer) business and there may not be sufficient time to organize the testing program before fall.

APPENDIX A

LETTERS FROM SOUTHWEST REGION, PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION, APPROVING FIELD TEST AT YUKON PLANT, MILL SERVICE, INC.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
-Please note our new name-
DEPARTMENT OF ENVIRONMENTAL PROTECTION
D E P
400 Waterfront Drive
Pittsburgh, PA 15222-4745
December 27, 1995

(412) 442-4000

Southwest Regional Office

Mr. Philip Costantini
Executive Vice-President
MAX Environmental Technologies, Inc.
1815 Washington Road
Pittsburgh, PA 15241-1498

RE: Mill Service, Inc.
Yukon Facility
U.S. DOE Research Project

Dear Mr. Costantini:

MAX Environmental's November 30, 1995 proposal to process a maximum of 200 tons of hazardous waste using coal ash as a stabilizing agent, followed as necessary by additional treatment using chemicals currently used at Mill Service's Yukon facility as part of the U.S. Department of Energy Clean Coal Technology By-Product Project is approved subject to the following conditions:

1. Mill Service should contact the Department (Carl Spadaro and Dave Leiford at our Greensburg Office) prior to commencement of treatment of hazardous waste with coal ash.

2. Mill Service should identify waste sources and type (including the hazardous characteristics) for this project.

3. Mill Service should identify the source of the coal ash and provide the Department with a copy of the analytical data as proposed in Carl Bender's November 16, 1995 response on behalf of Mill Service to our comments on Mill Service's waste stabilization and solidification permit modification request.

4. Coal ash may only be stored in enclosed devices at the Yukon plant.

5. Mill Service should submit a report to this office detailing the project including post-treatment analysis and final disposition of the waste within 60 days of project completion.

6. Mill Service is bound by the terms and conditions of Solid Waste Management Permits for all waste and material handling under this project.

If you have any questions please contact Carl Spadaro of this office.

Sincerely,

Anthony D. Orlando
Regional Manager
Waste Management

PENNSYLVANIA DER

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
-Please note our new name-
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DEP
400 Waterfront Drive
Pittsburgh, PA 15222-4745
February 20, 1996

(412) 442-4000

Southwest Regional Office

Ronald J. Sebek
R.D. #1, Cemetery Road
Yukon, PA 15698

RE: Plan Approval/Operating Permit
Application Determination
Type of Source: TSD Facility

Dear Mr. Sebek:

After reviewing, it has been determined that this source is exempted from the Plan Approval/Operating Permit requirements under Pa. Code §127.14(8).

We request that the company provide a progress report of this research project every three months.

This exemption does not affect your obligations to meet all applicable Pennsylvania Air Quality Regulations for this source.

If you have any questions, or require additional information, please contact this office.

Sincerely,

Noor Nahar

Noor Nahar
Air Pollution Control Engineer
Air Quality

APPENDIX B

PREPRINT OF "STABILIZATION OF METAL-LADEN HAZARDOUS WASTES USING LIME-CONTAINING ASH FROM TWO FBC'S AND A SPRAY-DRIER," 211th AMERICAN CHEMICAL SOCIETY NATIONAL MEETING AND EXHIBITION, NEW ORLEANS, LOUISIANA, MARCH 24-28, 1996

STABILIZATION OF METAL-LADEN HAZARDOUS WASTES USING LIME-CONTAINING ASH FROM TWO FBC's AND A SPRAY-DRIER

J. Cobb, R. D. Neufeld, J. Pritts and V. Clifford
School of Engineering, University of Pittsburgh, Pittsburgh, PA 15261
C. Bender, Mill Service Co.; J. Beeghly, Dravo Lime Company., Pittsburgh, PA

Keywords: clean coal technology by-product reclamation, hazardous waste management, chemical stabilization

ABSTRACT

Clean coal technology by-products, collected from commercial operations under steady state conditions, are reacted at bench-scale with metal-laden hazardous wastes. Reaction conditions involve mixing calibrated weight ratios of by-product to hazardous waste with attention to minimizing added moisture. Of the 15 heavy metals monitored, lead appeared to be the element of greatest concern both from a leaching and a regulatory point of view. While leaching information is focused on lead stabilization, similar information exists for other metals as well. Stabilized solid products of reactions are sampled for TCLP evaluations. For samples showing evidence of metal stabilization, further experimentation was conducted evaluating optimum moisture content and development of physical strength (measured as compressive strength) over time of curing. Results show that certain hazardous wastes are highly amenable to chemical stabilization, while others are not; certain by-products provided superior stabilization, but did not allow for strength generation over time.

INTRODUCTION

The general objective this two-year project (*which has just completed the first year*) is to provide useful information and data on the ability of new and emerging sources of chemical treatment substances, in this case by-products from advanced clean coal technologies, to be used by the hazardous waste management community. These studies fall into two categories: (i) characterization of selected critical properties of by-products and (ii) observation of their ability to stabilize and solidify characteristic metal-laden solid hazardous wastes. A more commercial objective of the project is to link the producers of by-product with operators of hazardous waste treatment facilities in a mutually profitable manner. From the treatment facility operators' point of view, new sources of treatment material with abilities to stabilize and solidify their feed wastes can be added to their material source list. From the producers' point of view, new uses for by-products of their advanced coal combustors and desulfurizers will be developed and demonstrated. These producers have implemented various emission control technologies at coal-fired (and coal waste fired) electric power plants and are studying a number of others. The technologies currently in use generate significant amounts of by-products with limited commercial value. Consequently, much of the by-products are disposed as solid wastes. In particular, companies employing wet scrubber technologies for the desulfurization of flue gases have found few alternatives to disposal for the sludges generated in the processes due to the excess moisture present in the by-product. On the other hand, the contemporary development of dry desulfurization technologies offers great promise that these process by-products may have beneficial commercial application, such as those studied as part of this project.

<u>Background:</u> The project focuses on <u>characteristic</u> metal-laden hazardous waste. Federal regulations and many state regulations require generators of solid wastes to determine if the wastes they produce are hazardous. The determination process requires the generators to analyze leachates produced when the wastes are mixed with an extraction fluid and compare the results of that analysis to a published list that defines which parameters are of concern and the extract concentrations at which a waste containing those parameters is considered hazardous. Wastes that contain extract constituents on the list at concentrations that equal or exceed the published concentrations are considered to be characteristically hazardous (unless they are specifically excluded) and said to exhibit the "toxicity characteristic". Among the parameters included on the toxicity characteristic list published in the Federal regulations[1] are eight metals; the

[1] See 40 CFR 261.24.

concentrations at which a waste extract containing them is considered hazardous, are:

Metal Parameter	Hazardous Concentration in Leachate (mg/l)
Arsenic (As)	5.0
Barium (Ba)	100.0
Cadmium (Cd)	1.0
Chromium (Cr)	5.0
Lead (Pb)	5.0
Mercury (Hg)	0.2
Selenium (Se)	1.0
Silver (Ag)	5.0

Once a waste is determined to be hazardous, generators are restricted from directly disposing that waste anywhere in the United States. Prior to disposal, the waste must be treated to an extent that renders the resulting waste non-hazardous. The purpose of the treatment prior to disposal is to reduce the likelihood of migration of hazardous waste constituents from the waste. Wastes that are treated to meet the established standards can be disposed.

For purposes of this first-year research, toxic metal-laden wastes were treated at bench-scale by stabilization and solidification methods. Stabilization/solidification is a treatment technology used to reduce the hazard potential of a waste by converting the contaminants into their least soluble, mobile, or toxic form. Solidification refers to techniques that encapsulate the waste in a monolithic solid of high structural integrity. Solidification does not necessarily involve a chemical interaction between the wastes and the solidifying reagents but may mechanically bind the waste into the monolith. Similarly, stabilization does not necessarily involve solidification, since precipitation and complexation are also mechanisms of stabilization.

BY-PRODUCTS

The Clean Coal Technology (CCT) Program is a cooperative effort to demonstrate a new generation of innovative coal processes, which are environmentally cleaner and more efficient than conventional coal-burning processes [US DOE, 1991]. In dry CCT systems, a calcium-based sorbent (usually slaked lime, limestone, or dolomite) is injected directly into a furnace, ductwork, precipitator, or scrubber vessel that produces powdered or granular by-products, as opposed to the slurries associated with traditional wet scrubber systems. All these processes produce a by-product which is removed in the particulate control equipment. Dry by-products from lime or limestone injected into the furnace, such as in FBC systems, have neutralizing, sorptive, and cementitious properties that make them interesting as potential reagents for hazardous waste stabilization because of their high free quicklime (CaO) and anhydrous calcium sulfate ($CaSO_4$) contents. The specific composition of a particular type of by-product may vary widely depending upon the CCT process employed, the coal and sorbent composition, and the plant operating conditions. Since the chemical, physical, and engineering properties of dry CCT by-products are directly related to their history of use within the system and specific mineralogy, it is essential to accurately determine the mineralogical composition of these wastes and process configurations if safe and economical uses are to be defined.

Four clean-coal technology by-products were originally identified, but only the first three were used in this research.

1- Dry Scrubber Residue, supplied by CONSOL Inc. This material is from a spray drier at the outlet of a pulverized coal boiler burning high-sulfur eastern coal. Within the process, ash laden flue gas enters the bottom of the spray drier and all of the sulfur-capture residue rises through the upper port with the fly ash. The residue contains 45% fly ash, 36% $CaSO_3/CaSO_4$, 10% $Ca(OH)_2$, 2% $CaCO_3$, and 7% other inert material with moisture content of 2% or less.

2- Residue from a Coal-Fired Pressurized Fluid Bed Combustor (PFBC) at the Tidd Station of Ohio Power Company. This demonstration facility was constructed and is operated in cooperation with the U.S. Department of Energy in Round I of the Clean Coal Technology Program. The sorbent fed to the plant, rather than lime or limestone, is dolomite. Dolomite is used at the Tidd Station because it is both more porous (and thus more reactive) and easier to handle without bridging in the piping system. By operating

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at high pressure, little of the dolomite in the residue is in the oxide form - most is present as carbonate. The dolomitic character of the sorbent yields a residue that is lower in pH than that produced from lime-based sorbents. This characteristic is particularly advantageous in stabilizing arsenic-laden waste solids. As this by-product contains magnesium, it will buffer the stronger lime alkalinity. The chemical composition of the residue is 50-60% equivalent $CaCO_3$ and 1-2% available (free or uncombined) CaO.

3- Residue from a Coal-Waste-Fired CFBC operated by the Ebensburg Power Company. Approximately 200,000 tons/year of this material is trucked back to the mines from which the coal wastes are derived. Some or all of this by-product could be diverted to nearby sites for beneficial use if they could be identified. The coal waste fed to the boiler has a sulfur content between 1.4 and 2.0 percent. The limestone is 83% $CaCO_3$. It is sized at 12 mesh x 0 and contains between 5 and 10 percent through 140 mesh. The fly ash is removed in a ten-segment baghouse and conveyed to a silo. Approximately 70% of the by-product in the silo is baghouse ash; 30% is bottom ash. Thus, the by-product is a relatively coarse material containing 82% ash, 12.5% limestone equivalent and 5.5% $CaSO_3/CaSO_4$.

4- Residue from a Coal-Fired Circulating Fluid Bed Combustor (CFBC), supplied by Anker Energy Corporation. This material is produced by the cogeneration project of Applied Energy Service at its Thames River Plant near Uncasville, Connecticut. Anker Energy Corporation supplies the coal used in the plant and through early 1995 had to backhaul the residue to its mines in West Virginia. It was anticipated that some or all of the approximately 100,000 tons/year of this by-product could be easily diverted to hazardous waste treatment plants along the general rail route from Connecticut to West Virginia. The AES Thames River Plant is base-loaded, operating at 95-96 percent of capacity constantly, thus the ash from it is very uniform. The residue is a relatively coarse material, as it contains both bottom and fly ash from the boiler, and contains 45% limestone equivalent, 28% ash and 27% $CaSO_3/CaSO_4$. Dravo Lime Company provided assistance in obtaining and transporting multiple representative samples from each clean coal technology site in accordance with ASTM-C-311. Samples were split for analysis and use at the University of Pittsburgh and the Dravo Lime Company.

HAZARDOUS WASTES

Six different hazardous wastes have been selected for examination by Mill Service, Inc., a regional centralized hazardous waste treater, from among the materials processed commercially at their facility. The table below outlines significant properties of each hazardous waste: note that lead is the contaminant of primary concern since it is the TCLP lead levels that exceed appropriate limits.

HAZARDOUS WASTES STABILIZED

Hazardous Waste Source	Hazardous Constituents of Concern	Total Concentration (mg/kg solids)	TCLP Concentration (mg/l)	TCLP Regulatory Limit (mg/l)
Sludge from Lead-Acid Storage Battery Production	Lead	3,000	20	5.0
	Cadmium	3	0.19	1.0
	Chromium	12	—	5.0
Contaminated Soil from a Munitions Depot	Lead	1,200	26	5.0
	Cadmium	4.8	—	1.0
	Chromium	59	—	5.0
	Copper	210	1.6	—
	Zinc	580	8.2	—
Contaminated Soil from a Multi-Use Industrial Site	Lead	5,000	80	5.0
	Cadmium	5.4	—	1.0
	Chromium	22	—	5.0
	Copper	260	—	—
	Zinc	660	17	—

Baghouse Dust from Basic Oxygen Furnace (BOF) Steelmaking	Lead Cadmium Chromium Copper Nickel Vanadium Zinc	1,400 55 260 57 130 76 41,000	14 — — — — — 4.4	5.0 1.0 5.0 — — — —
Ash from a Municipal Solid Waste Incinerator	Lead Barium Cadmium Chromium Copper Zinc	5,700 550 630 130 1,300 23,000	20 — — — — 2.1	5.0 100 1.0 5.0 — —
Contaminated Soil from a Former Waste Water Treatment Plant	Lead	750	7.8	5.0

RESULTS & CONCLUSIONS

Bench-scale stabilization experiments consisted of mixing by-products with hazardous wastes at weight ratios ranging from 0 to 1:2 with minimal moisture addition. Sampling of the stabilized mass was done immediately after treatment for evaluation of TCLP leachate compositions. As may be expected, some combinations of by-product/wastes exhibited stabilization more consistently than others. Figures 1 and 2 provide contrasting resultant information for two representative sets of stabilization experiments: figure 1 shows information illustrating lead stabilization while figure 2 shows failure to stabilize lead.

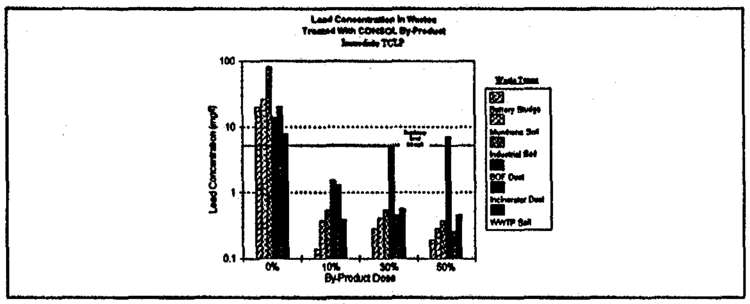

Figure 1
Successful Lead Stabilization

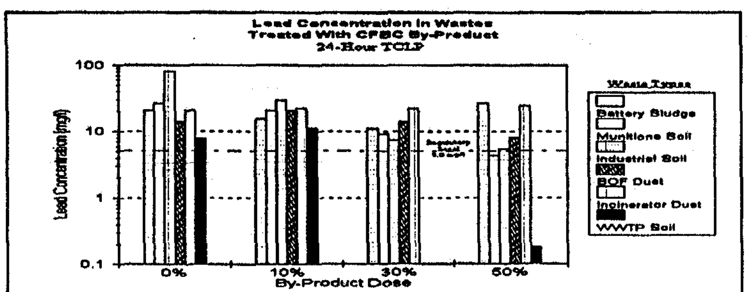

Figure 2
Unsuccessful Lead Stabilization

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Solidification/Strength Development: In addition to chemical stabilization, aliquots of hazardous waste and by-products were evaluated for development of strength over time when prepared at optimal moisture contents. Optimal moisture values were determined to be that at which the "stiffened" mass would produce a "slump" in the neighborhood of 1 inch to 2 inches when tested in accordance with standard concrete testing procedures. Figure 3, a representative plot of compressive strength development over time, indicates that for some samples, strength development is considerable while little strength development is achieved for others.

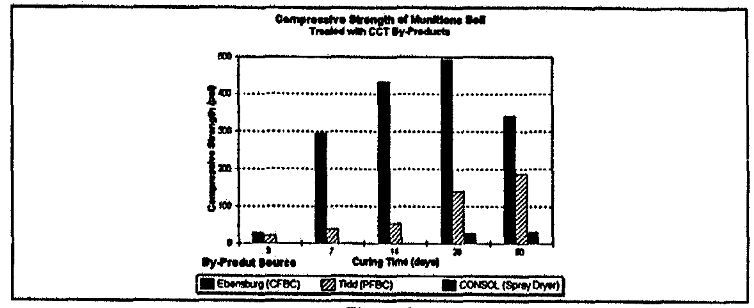

Figure 3
Strength Development over Time

SUMMARY

- Clean Coal Technology by-products may be used for heavy metal stabilization of a number of hazardous waste sources, however laboratory evaluations must be conducted to assure final product quality.
- Pozzolanic properties of clean coal technology by-products are useful in making a hardened product for reuse or disposal.
- By-products producing a highly stabilized materials do not often produce the strongest product. Thus, evaluation of final product use and/or disposal options must be made on a case-by-case basis.
- Commercial-scale stabilization testing will be undertaken during the second year of this project in conjunction with developing an understanding of underlying principles governing the behavior of these new treatment chemicals.

REFERENCES:

"Clean Coal Technology - The New Coal Era", Washington, DC: U.S. Department of Energy, Assistant Secretary for Fossil Energy, January, 1991.

ACKNOWLEDGMENT:

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APPENDIX C

SUMMARY OF POSTER ON "HAZARDOUS WASTE STABILIZATION WITH CLEAN-COAL TECHNOLOGY ASH RESIDUALS," TO BE PRESENTED AT THE IAWQ 18th BIENNIAL INTERNATIONAL CONFERENCE, SINGAPORE, JUNE 23-28, 1996

Preproposal

Stabilization of DOE Hazardous Wastes with Clean-Coal Technology By-Products

R. D. Neufeld, J. T. Cobb
University of Pittsburgh
Pittsburgh, PA 15261

The objective of this research is to evaluate both the long term and short term stabilization of DOE metal-containing hazardous wastes with clean coal technology by-products. This work builds directly on a currently funded DOE/METC project with the University of Pittsburgh (prime contractor) in conjunction with Mill Service (a centralized waste treater), and Dravo Lime Corporation.

BACKGROUND: The overall objective this project is to provide useful information and data on the ability of by-products from advanced Clean Coal Technologies (CCT) to be used by the DOE in an engineered effort to stabilize and reduce the risks from exposure to selected metal containing hazardous wastes. Studies fall into two categories:

- (i) observation of the ability of CCT to stabilize and solidify characteristic toxic/hazardous metal-laden wastes *(and other DOE metal containing wastes)* over the near term via conversion of such wastes into a non-hazardous form by means of pozzolanic type reactions with by-products, and;
- (ii) characterization and understanding of the longer term environmental and physical stability of the resultant solidified matrix in terms of potentially time dependent physical and chemical/toxicological leaching characteristics taking place due to slow solid phase crystalline reactions.

BY-PRODUCTS The Clean Coal Technology (CCT) Program is a DOE-Utility cooperative effort to demonstrate a new generation of innovative coal processes, which are environmentally cleaner and more efficient than conventional coal-burning techniques. In dry CCT systems, a calcium-based sorbent (usually slaked lime, limestone, or dolomite) is injected directly into a furnace, ductwork, precipitator, or scrubber vessel that produces powdered or granular by-products, as opposed to the slurries associated with traditional wet scrubber systems. All these processes produce a by-product which is removed in the particulate control equipment. Dry by-products from lime or limestone injected into the furnace, such as in FBC systems, have neutralizing, sorptive, and cementitious properties that make them interesting as potential reagents for hazardous waste stabilization because of their high free quicklime (CaO) and anhydrous calcium sulfate ($CaSO_4$)

contents. The specific composition of a particular type of by-product varies widely depending upon the CCT process employed, the coal and sorbent composition, and the plant operating conditions. For purposes of this research, the University will initially select CCT byproducts which have already proven to be useful for the metal-sludge and metal-soil stabilization purposes, followed by selection of additional CCT materials in conjunction with DOE personnel. The initial group of clean-coal technology by-products include:

1- Dry Scrubber Residue, supplied by **CONSOL Inc.** This material is from a spray drier at the outlet of a pulverized coal boiler burning high-sulfur eastern coal. Within the process, ash laden flue gas enters the bottom of the spray drier and all of the sulfur-capture residue rises through the upper port with the fly ash. The residue contains 45% fly ash, 36% $CaSO_3/CaSO_4$, 10% $Ca(OH)_2$, 2% $CaCO_3$, and 7% other inert material with moisture content of 2% or less; and

2- Residue from a Coal-Waste-Fired CFBC operated by the **Ebensburg Power Company.** Fly ash is removed in a ten-segment baghouse and conveyed to a silo with the resultant mixture being 30% bottom ash. Thus, the by-product is a relatively coarse material containing 82% ash, 12.5% limestone equivalent and 5.5% $CaSO_3/CaSO_4$.

CCT materials that will not be considered further for this proposal, but are part of our existing effort include:

- *Residue from a Coal-Fired Pressurized Fluid Bed Combustor (PFBC) at the* ***Tidd Station of Ohio Power Company*** *(this materials will no longer be generated and will not be considered further), and*

- *Residue from a Coal-Fired Circulating Fluid Bed Combustor (CFBC), supplied by Anker Energy Corporation at its Thames River Plant near Uncasville, Connecticut. The residue is a relatively coarse material, as it contains both bottom and fly ash from the boiler, and contains 45% limestone equivalent, 28% ash and 27%* $CaSO_3/CaSO_4$*. Special permission from the generator will be required for this material.*

The proposed research will use one or both of the CCT materials above **in conjunction with other candidate CCT by-products as can be identified later.**

- **Preliminary Results:** Results to date have shown that **CONSOL** spray drier CCT by-products exhibit across-the-board superior lead stabilization properties for all hazardous wastes utilized. The waste products indicated on Figure 1 were obtained from Mill Service Company clients. The stabilization ability of such CCT materials with <u>DOE hazardous wastes</u> must still be determined.

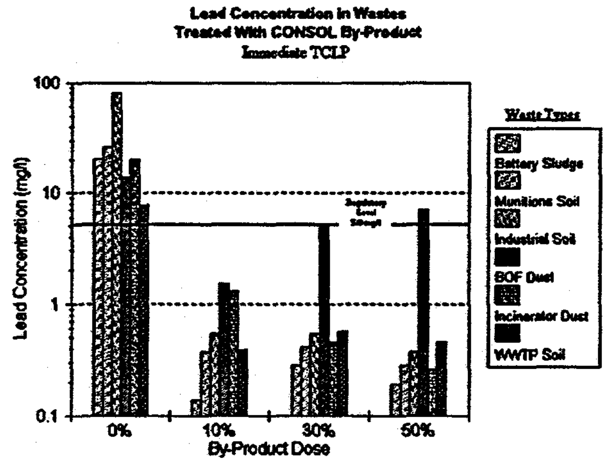

Figure 1
Successful Lead Stabilization

In addition, compressive strength properties of solidified materials will be determined (*equipment contained within the Department's Geotechnical Engineering laboratory*) to supplement measured leaching potential thus allowing considerations of reuse opportunities for treated materials.

Objective 2: Longer term stabilization: Regulatory and risk assessment acceptability determinations are often made based on information from short term leaching and stabilization experiments. In contrast, recent data at the University of Pittsburgh shows that in some cased leachate concentrations (and thus ingestion risks) resulting from stabilized/solidified matrices are elevated over time, probably as a consequence of solid phase reactions continuing to take place.

Tables 1a & 1b illustrate this point by showing current results of leachate concentrations measured just after stabilization, and made after waiting 90 days after stabilization and solidification. Such chemical (and physical) alterations over time may be indicative of critical but slow aging processes taking place within the solid phase. Both short term and longer term (> 90 days) controlled experimentation using DOE wastes are proposed for this new effort.

Evaluation of Lead Stabilization at 90 Days
Hazardous Waste Mixtures Treated with
Clean Coal Technology By-Products
Lead TCLP Concentrations (mg/L)

Table 1-a: Stable Mixtures over Time-Pb (mg/L)

Stabilization Time (days)	Tidd with Battery Sludge	Tidd with Waste Soils	Tidd with Munitions Soil
0	4.1	2.3	1.2
90	0.7	0.6	1.2

Table 1-b: Mixtures showing Increasing Leachate Concentrations over Time-Pb (mg/L)

Stabilization Time (days)	CONSOL with Munitions Soil	Ebensburg with Waste Soil	Ebensburg with Munitions Soil	Tidd with Industrial Soil
0	0.28	0.31	5.6	1.7
90	0.90	6.0	9.0	14.0

This is a significant issue since, as shown on Table 1b, there is a real potential that environmental management decisions based on immediate or 24 hour TCLP measurements (after initial stabilization) may be in error as a consequence of inherent longer term aging reactions.

For purposes of this research, specially collected and stabilized samples of solidified DOE hazardous wastes will be stored in humidified chambers for the duration of the project (for time periods on the order of 1 to 2 ½ years). Solidified materials will be examined at periodic time intervals using XRD analysis (*located within the Department of Materials Science*) to determine the nature of slow solid phase crystalline reactions taking place. Such reactions will be compared and correlated with leachate and compressive strength determinations both from short term and longer term evaluations.

SUMMARY and EXPECTED OUTCOMES

- Research will examine the use of Clean Coal Technology by-products (CCT) as a chemical feedstock for the stabilization and leachate attenuation of DOE hazardous wastes.

- Based on preliminary results of current research, a number of CCT materials are identified as being particularly promising for stabilization and leachate attenuation.

- Critical issues are identified of both short term (24 hour) stabilization/leachate attenuation reactions, and "aging" reactions which must be evaluated and understood to assure longer term decreased risk for the public and workers associated with DOE environmental management and restoration actions.

- This research is uniquely multidisciplinary in nature involving faculty and expertise from the areas of environmental engineering, energy resource engineering, geotechnical engineering, and materials science and engineering. Faculty and necessary laboratory facilities are all located within the School of Engineering, University of Pittsburgh.